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(54) **Electrochemical gas sensor.**

(57) An electrochemical gas sensor for detecting gas components in the environment has a diffusion membrane 11, a measuring electrode 12, and optionally a reference electrode (24), pressed together in a disc stack accommodated in a vessel-like cover 2. The cover 2 is flanged around and insulated from, the sealing edge 6 of a vessel-like housing 1 which contains counter electrode 28, electrolyte, and wick 19 incorporating wick plate 20. A compression spring 21 in the vessel-like housing 1 presses wick plate 20 against the measuring electrode 12.

Gas enters the sensor through holes 9, pressure disc 10 and diffusion membrane 11 and the disc stack is held together both by spring pressure and by fusion adhesive films 14. The outer periphery of the measuring electrode comprises a contact surface 15 which provides electrical contact to the metallic cover 2.

When a reference electrode (24) is present, it is porous, located between the necessary electrode and the wick plate and has side portions which are insulated from cover 2 and housing 1 and with which contact is made through the gap between cover 20 housing 1.

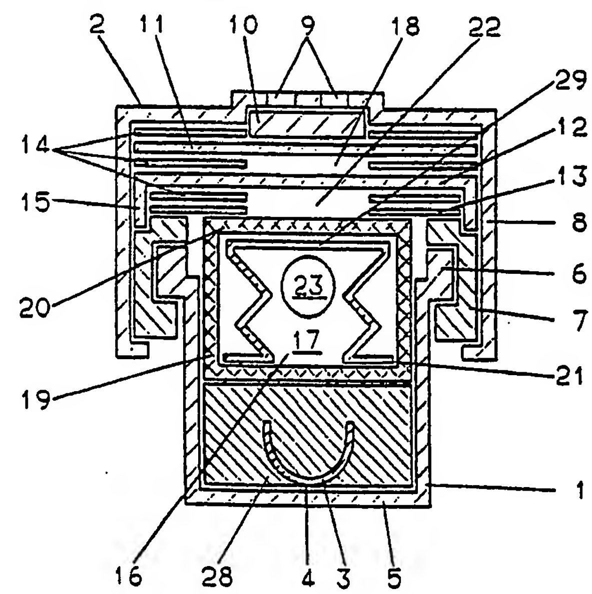

Fig. 1

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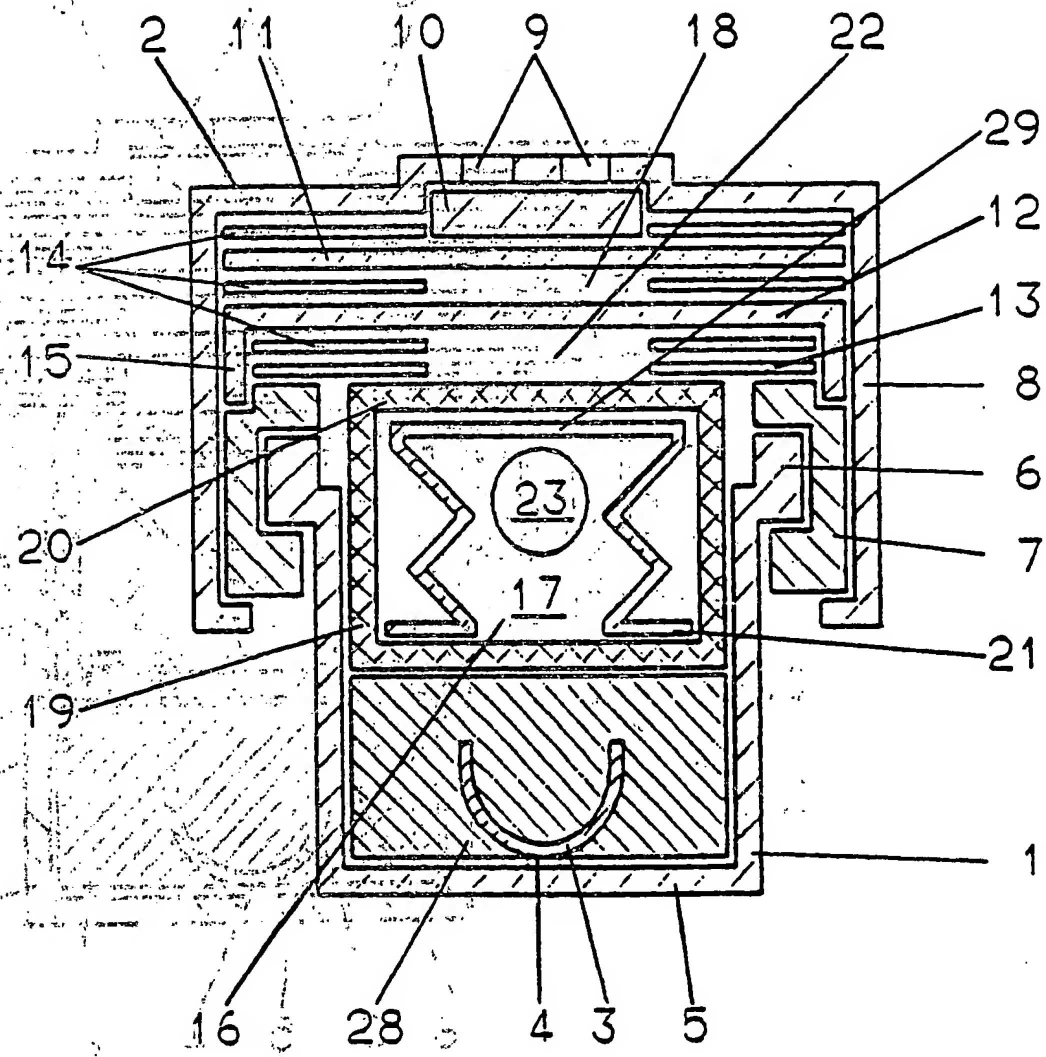

Fig. 1

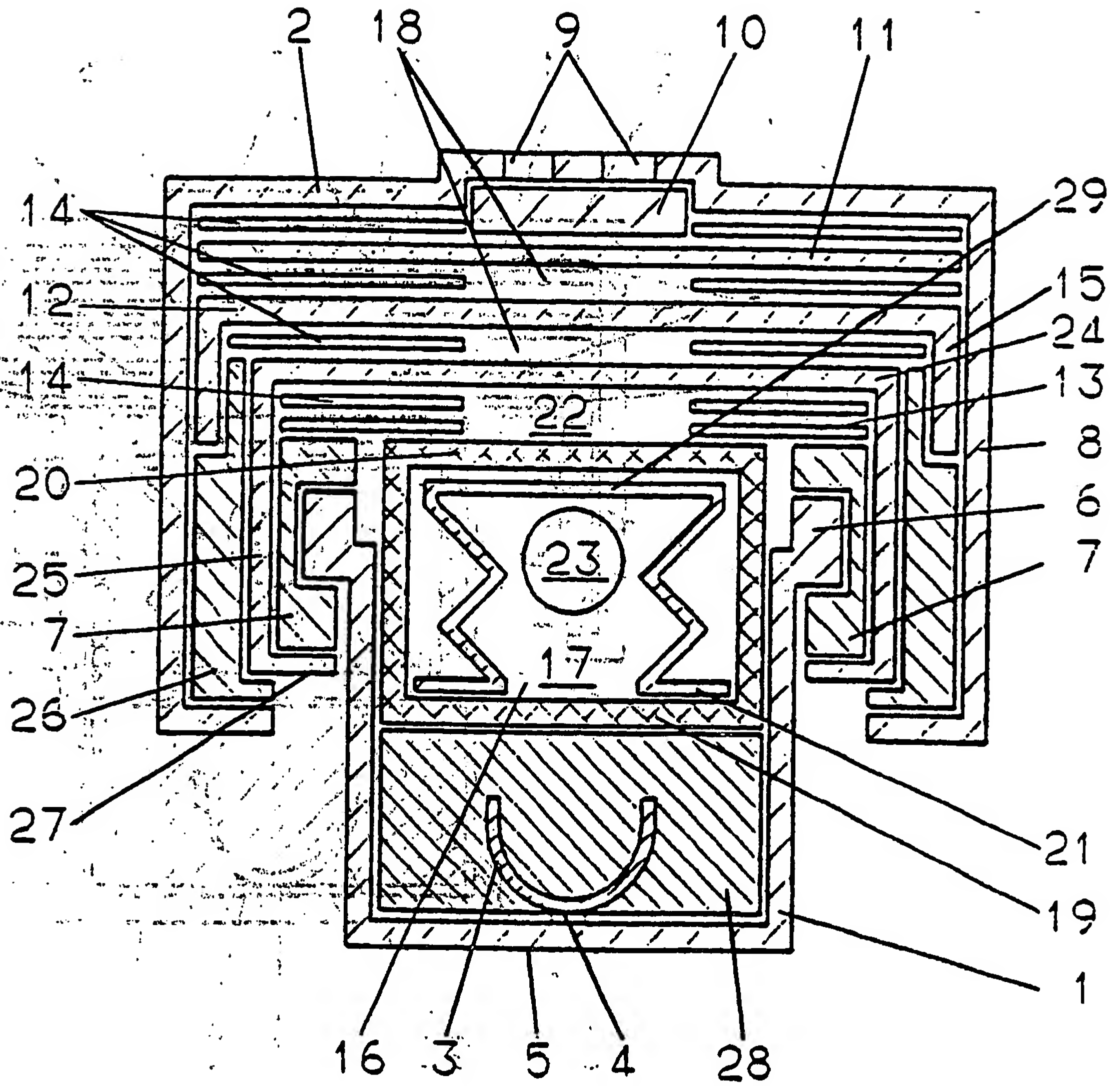
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Fig. 2

ELECTROCHEMICAL GAS SENSOR

The invention relates to an electrochemical gas sensor for detecting gas components in a gaseous environment.

A electrochemical gas sensor is disclosed in GB-A-2075197. This known sensor has a vessel-like housing in the base of which there is accommodated a counter electrode which is in electrical contact with the housing which, moreover, contains the electrolyte required for the detection of the gas. The open edge of the housing is provided with an inwardly-extending peripheral groove on which an electrically-insulating sealing ring having an L-shaped cross-section is placed. The supporting edge of the sealing ring, projecting inwardly, serves to accommodate, in sequence starting from the electrolyte, a wick plate over which wick plate a disc-like measuring electrode is laid, which in turn is covered by a plate of polytetrafluoroethylene (PTFE) as a diffusion member. A disc-like cover, having a central bore for the entry of the gas component to be detected, seals the housing. A metallic contact strip is laid on the reaction-sensitive surface of the measuring electrode, which strip projects well beyond the cross-section of the sealing ring.

Upon completion of the disc stack, sealed by the metallic cover, the edge of the housing is pressed around the disc stack and clamps the stack as a whole against the peripheral groove. Accordingly, the contact strip between the disc edges and the sealing edge is pressed upwardly in the direction of the metal cover and turned over, so that it is brought, on the one hand, into clamping contact with the surface of the measuring electrode and, on the other hand, with the metal cover. The housing forms one electrical contact of the counter electrode, and the cover disc forms the

other electrical contact for the measuring electrode, for connection to a measuring and evaluating unit.

Depending on the composition of the electrolyte and the electrode materials used, the sensor is able to be used for detecting different oxidising or reducing gases. There are two different embodiments of the known sensor, namely a so-called "two-electrode" embodiment which, in addition to the measuring electrode, has only the counter electrode, and a so-called "three-electrode" embodiment which has in addition a reference electrode which is kept at a constant reference potential relative to the measuring electrode by a potentiostat.

In the known gas sensor, it is a disadvantage that the contact strip in the disc stack, despite being tightly pressed, leaves open a small capillary section through which the electrolyte can advance to the sealing disc so as therefore to form to a certain extent a short-circuit section in which a three-phase boundary (gas/electrolyte/measuring electrolyte) is present which is brought into contact with the counter electrode. A surface is thereby produced which is active, although only slightly, and which however falsifies the measuring result and is superposed on the desired sensor signal.

This interfering influence is greater, the smaller the desired sensor current. With today's increasing miniaturisation, even of the gas sensors themselves and not only of evaluating electronics, it is of particular importance that the sensors work with as low a measuring current as possible, in order to obtain a long life even with a small amount of electrolyte as in a miniature sensor. Each interfering current, even it is still so small, thereby acts in a manner so as to falsify the measuring value.

A further disadvantage is that, when pressing the

edge of the housing onto the cover disc, the disc stack is pressed into the cavity of the housing so that the individual discs bulge to a lesser or greater extent because they have no central support. In this way electrolyte films of varying thickness form between the individual discs and in particular on the surface of the measuring electrode so that varying diffusion paths for the gas to be detected are produced and so that also small air bubbles are held in the intermediate chambers. Both events affect the sensor behaviour disadvantageously in relation to its reaction time and its long-time stability.

The object of the present invention is to improve an electrochemical gas sensor so that additional contact members for connecting the electrodes to the exterior of the sensor can be omitted, whereby a still more intimate compression of the disc stack in the electrode region results in a constantly stable electrolyte film on the surface of the measuring electrode.

According to the present invention, there is provided an electrochemical gas sensor for detecting a gas component in a gaseous environment, comprising:

a disc-like measuring electrode to which the component to be detected has access by way of a disc-like diffusion section;

a counter electrode which, together with the measuring electrode, is accommodated in an electrolyte chamber containing an electrolyte inside a vessel-like housing which is in electrical contact with the counter electrode;

a wick immersed in the electrolyte and having a wick plate which bears on the surface of the measuring electrode on the electrolyte side;

a cover which is in electrical contact with the measuring electrode and which seals the vessel-like

housing on the gas side and is separated electrically by a sealing ring from the vessel-like housing;

wherein the cover is a vessel-like cover and has an edge that projects over the outside of the vessel-like housing and accommodates at least the diffusion section and the measuring electrode, the latter having a contact surface;

wherein the sealing ring is disposed around the edge of the vessel-like housing such that, on the one hand, by clamping of the vessel-like cover on the edge of the vessel-like housing, electrical insulation is achieved between the vessel-like cover and the vessel-like housing and, on the other hand, the disc stack is displaced under the effect of pressure against the wick plate which, for its part, is pushed against the disc stack by the presence of a compression spring between the wick plate and the vessel-like housing; and

wherein the edge of the vessel-like cover contacts the contact surface of the measuring electrode and thus forms a contact point for a measuring and evaluating unit.

The present invention also provides, in a preferred embodiment, such an electrochemical gas sensor, wherein, between the measuring electrode and the counter electrode, there is arranged a disc-like reference electrode having an edge which projects over the edge of the vessel-like housing and is disposed around it in a sealing manner;

wherein the sealing ring serves as electrical insulation between the reference electrode and the vessel-like housing;

wherein the edge of the reference electrode is separated from the vessel-like cover by an insulating member; and

wherein, on the edge of the reference electrode around the edge of the vessel-like housing, a contact

region is available for connection of the measuring and evaluating unit.

According to the invention in the case of a "two-electrode" sensor, the cover is formed like a vessel and with its cover edge projects over the vessel-like housing from outside and accommodates at least the diffusion section and the measuring electrode provided with a contact surface located on the electrode surface. The sealing ring is laid around a sealing edge forming the edge of the vessel-like housing such that, on the one hand, with a sealing clamping of the cover on the sealing edge, an electrical insulation is formed between the cover and the vessel-like housing and, on the other hand, the disc stack is displaced under the effect of pressure against the wick plate, which for its part, is pushed against the disc stack by the presence of the compression spring supported between the wick plate and the vessel-like housing. The cover edge bears against the contact surface of the measuring electrode and thus forms the contact point for the measuring and evaluating unit.

In the case of the "three-electrode" sensor, between the measuring electrode and the counter electrode, there is arranged the disc-like reference electrode, which is provided with a contact edge which projects over the edge of the vessel-like housing and is laid around this in a sealing manner. The sealing ring serves as an electrical insulation between the reference electrode and the vessel-like housing. The contact edge opposite the cover is separated by an insulating member and, on the contact edge around the edge of the vessel-like housing, a contact region is open for the connection of the measuring and evaluating unit.

The advantage of the invention is that the electrolyte chamber and the disc-like electrodes

accommodated in the vessel-like cover and the diffusion section are hermetically sealed relative to the environment, without the need of any separate contact leads passing through the housing or the cover, so that no capillary gaps for the electrolyte are formed and so that no additional sealing measures (which are always insufficient in their effect) have to be taken. For the mechanical construction of the sensor, it is merely necessary that the disc stack be pressed firmly against the wick plate and that a contact which is as intimate as possible between the electrolyte film and the measuring electrode be produced, without there being any bulging or warping of the discs inside the disc stack. Through the spring force, on the one hand, and the counter pressure produced by the vessel-like cover, on the other hand, the disc stack is crushed together in a regular manner.

The connection between the vessel-like cover and the edge of the vessel-like housing can be realised by a screw connection or, in a simple case, by flanging of the edge of the cover with the edge of the housing, with a sealing ring being squeezed at the same time against the edge of the housing having a flanged edge. In this case, it is possible to use the same method for sealing the cover and housing as used when producing round or button-like battery cells. As a consequence of the tight pressing together of the individual discs which form the electrodes, and the wick plate, to form a sealed disc stack, it is possible to achieve the smallest possible sensor currents for detecting the gas components to be examined, since the diffusion sections are minimised. The result is an equally long life even with a small electrolyte supply, as can be achieved with the known gas sensors. In this way one can talk of a type of button cell with regard to the type of construction as well as with regard to its outer dimensions.

As a consequence of the intimate contact of the measuring electrode with the surface of the vessel-like cover, a good thermal contact is achieved between these components, since the cover can be made of metallic electrically-conductive material. Because the sensor current is dependent on the temperature, variations in the temperature between the electrolyte temperature (i.e. the electrode temperature) and the ambient temperature (i.e. the gas temperature) are quickly compensated for. This increases the temperature stability of the sensor and assists in its measuring stability.

Since a specific electrical contact point on the cover is not required, because the whole surface of the cover, including its edge extending over the edge of the housing, is available as an electrical contact, the user has great freedom when introducing the sensor into an enclosure, since the place for the attachment of the electrical contact can be selected relatively freely. Only in the case of the three-electrode sensor is an additional contact surface provided on the edge of the reference electrode, for the application of an electrode voltage.

In order to detect any temperature variation influencing the measuring results and requiring correction of the measuring signal, on the outer periphery of the housing and of the cover, a temperature-sensitive sensing element can be provided, for producing a temperature signal that is made available to the measuring and evaluating unit. In the case of a button-like cell, variations in temperature occur substantially quicker than in the case of traditionally known sensors, because of the miniaturisation of the former.

The sealing of the individual discs in the disc stack can be affected by the application of a fusion

adhesive in the edge region of the discs so that, as a result of the contact pressure which is applied to the disc stack, an electrolyte-tight and gas-tight connection between the individual discs, on the one hand, and the cover as well as the other sealing elements, on the other hand, is guaranteed. A sealing method, as well as suitable adhesive films, are described in DE-A-2311096 and can be used for the present sensor. Suitable adhesive films include "Hostaflon PFA" commercially available from Hoechst AG.

In order to achieve a good contact surface between the measuring electrode and the edge of the cover, it is advantageous to have a metallic contact edge running around the outer periphery of the disc. This can be achieved by shaping the measuring electrode in the form of a shell or dish, so that the edge of the dish lies in close contact with the inner surface of the cover. Through the embedding of the disc stack into the cover and the subsequent connection of the cover to the edge of the vessel-like housing, an elastic pressing of the cover against the contact edge is achieved which is still further favoured if, in order to attach and secure the cover to the edge of the vessel-like housing, the cover edge is flanged and when flanging an additional pressure of the cover edge is applied to the contact edge of the measuring electrode.

In order for the gas components to be detected to enter the electrolyte chamber of the sensor, the cover is provided with access openings which can be sealed by a porous pressure disc, to which is connected the diffusion membrane serving as a diffusion section, which, in turn, is followed by the measuring electrode. The pressure disc, together with the diffusion membrane and the measuring electrode, thereby form a stable covering conforming to the contours of the cover, which can be adapted to the various mechanical effects of

pressure.

In a preferred embodiment, the wick is formed as a hollow body which is filled on the one hand with the electrolyte and, on the other hand, contains the compression spring, which has a spring plate which rests against the surface of the wick plate on the electrolyte side. In this manner the electrolyte is conveyed only by way of the wick plate to the active surface of the measuring electrode, as a result of which electrolyte transport occurs solely through diffusion of the electrolyte through the pores of the absorbent fleece of the wick. The hollow body forming the wick can either be closed on all sides (i.e. in th form of a closed hollow "box" all six sides of which consist of the absorbent fleece, the "box" thereby confirming any gas bubble formed therein) or it can be formed from a rectangularly-shaped shell from a fleece line so that two opposing sides are open, wherein however a fleece surface of the shell forms the wick plate resting on the measuring electrode surface (i.e. in the form of an open hollow "box" two opposing sides of which are open and the remaining four sides of which consist of the absorbent fleece, the two open sides being spaced from the housing or being closed by the housing).

In order to facilitate unhindered transport and exchange of used electrolyte with unused electrolyte in the electrolyte chamber, the spring plate resting on the wick plate can be provided with perforations.

In order to fix the active surface of the measuring electrode accurately, it is favourable if the wick plate is covered, up to the measuring electrode, with a partition plate so that only one limited (but accurately definable) sub-region of the wick plate is left open and in electrolyte contact with the measuring electrode.

As a consequence of the complete covering of the active surface of the measuring electrode by the wick plate, and as a consequence of the pressure on the whole disc stacking being maintained, it is ensured that the charge transport during the reaction of the gas to be detected on the electrode surface, as well as the material transport of the reaction products, occur exclusively by way of a diffusion process, which is the rate-determining step. Any competing convection transport, which would lead to a gas bubble formation in the electrolyte layer on the active surface of the measuring electrode surface and would therefore falsify the measuring signal, is effectively prevented in this way.

A suitable measuring electrode is a gold-plated nickel gauze in the form of a dish or shell, the edge of which bears as a contact surface against the inner wall of the cover.

The individual discs of the disc stack are pressed against each other, under each other, and can be sealed to the cover by means of fusion adhesive discs such as those made of FEP (i.e. fluoroethylenepropylene) or PFA (i.e. perfluoroalkyl) derivatives, examples of the latter being disclosed in DE-A-2311096, for example Teflon PFA and Hostaflon PFA (i.e. polytetrafluoroethylene having PFA side chains such as $C_nF_{2n+1}O$- or $C_nF_{n+1}O$- side chains).

Alterations of the ambient pressure, thermal effects and the diffusion effects of interfering gases should not result in either lifting of the diffusion membrane from the active surface of the measuring electrode surface, or in leakages. A pressure compensation system, known from the art, compensates for such alterations. In the case of the present invention, this system is available in a simple manner in that, in the cavity formed by the wick, there can be

enclosed a gas bubble. The pressure balancing membranes known from the state of the art, which make necessary an additional sealing expense in the sensor housing and thus form possible leakage points for the electrolyte or diffusion points for the entry of gas at an undesired point, can therefore be omitted. The gas bubble itself now forms the compressible component of the electrolyte liquid, and can yield to variations in pressure and temperature.

A suitable counter electrode is a pressed metal granulate that is pressed into the vessel-like housing, a contact gauze being embedded in the granulate, which gauze is connected electrically at a contact point to the vessel-like housing. The contact gauze should contact the metal granulate over the largest possible area so as thus to improve the electrical conductivity which otherwise occurs by way of contact points on the individual granules and therefore do not provide an ideal electrical connection. The contact gauze is connected, in an electrically conductive manner, by way of the contact point, for example by means of spot welding, to the sensor housing and thus provides an improved flow of the current to the counter electrode. With such a design of the sensor, it is advantageous for the compression spring to be clamped between the wick plate and the counter electrode so that it not only applies pressure to the disc stack in the cover, but in addition provides an increased contact pressure of the granulate particles with each other and with the contact gauze, on the one hand, and the inner wall of the vessel-like housing, on the other hand.

The electrochemical gas sensor is particularly suitable for the measurement of oxygen in ambient air, when the measuring electrode as the cathode consists of a gold-plated nickel gauze, the electrolyte consists of a KOH solution and the anode consists of a pressed lead

granulate member. By a corresponding selection of other electrode materials and electrolytes, other gas components are also able to be measured with the gas sensor.

When acidic or corrosive electrolytes are used, it is advantageous to provide the inner wall of the vessel-like housing with a gold lining as a corrosion-resistant coating.

For a better understand of the invention, reference will now be made, by way of example, to the drawings in which:

Figure 1 is a section through a "two-electrode" sensor of the invention; and

Figure 2 is a section through a "three-electrode" sensor of the invention.

The sensor represented in Figure 1 is used for detecting oxygen in ambient air. The structural components thereof, determining its outer shape, consist of a vessel-like housing 1 and a vessel-like cover 2. In the housing 1, there is located, as a counter electrode 28, an anode consisting of pressed lead granulate in which a vessel-like contact gauze 3 is embedded, which gauze is connected electrically by spot welding to a contact point 4 on the base of the housing 1. The housing 1 is produced by deep-drawing a metallic member and thus its whole outer surface forms the anode contact.

The housing 1 is cylindrical, so that is sealing edge 6, opposite the base 5 of the housing 1 is circular. The sealing edge 6 is offset outwardly relative to the remainder of the housing 1 and serves as receiver for a sealing ring 7. The cover 2, embracing the sealing ring 7 and the sealing edge 6, is slipped over the housing 1. The wall 8 of the cover 2 embraces the sealing ring 7, and is flanged around the sealing edge 6.

The cover 2 contains a disc stack which, starting from the gas inlet openings 9 towards the environment, consists of a pressure disc 10, a diffusion membrane 11, a measuring electrode 12 and a partition plate 13. The circular disc stack is held and sealed on the one hand relative to the metallic cover 2 as well as on the other hand relative to the individual adjacent discs, by means of fusion adhesive films 14. The measuring electrode 12 has, on its outer circular periphery, a contact surface 15 which is in all around electrical and thermal contact with the wall 8 of the cover 2.

The partition plate 13, as well as the adhesive films 14 serving as sealing discs, are provided in their centre with a perforation which, on the one hand, exposes the measuring surface of the measuring electrode 12 to an electrolyte 17 located in an electrolyte chamber 16, and, on the other hand, produces an electrolyte layer 18 between the diffusion membrane 11 and the measuring electrode 12. The diffusion membrane 11 is permeable to oxygen but impermeable to the electrolyte 17. The measuring electrode 12 (i.e. the cathode), which is also permeable to the electrolyte, consists of a perforated plate of gold-plated nickel, which is bent at its outer edge to form the contact surface 15.

In the electrolyte chamber 16, there is located a rectangularly shaped wick 19 in the form of a hollow body, the two visible surfaces of which are open in Figure 1. The wick 19 consists of a fleece-like material and has a wick plate 20 facing the measuring electrode 12. The hollow wick 19 contains a compression spring 21 having a spring plate 29 which presses the wick plate 20 firmly against the measuring electrode 12 so that the wick plate 20 is spaced from the measuring electrode 12 merely by the partition plate 13 and the sealing disc 14 lying ther b tween.

The circular partition plate 13 forms a further el ctrolyte layer 22 which is filled with the el ctrolyte 17. A gas bubble 23 is enclosed by the hollow wick 19.

The individual parts represented in the Figure are shown spaced from each other, in order to be distinguished from each other. It is to be understood however that, in the assembled state, as a result of sealing of the disc stack as well as of the flanging of the wall 8 around the sealing edge 6 and the crushing of the sealing ring 7 resulting therefrom, an intimate connection of the disc stack occurs, due to the effect of the pressure between the cover 2 and the compression spring 21. The spacing shown in the Figure disappears, and the electrolyte layers 18 and 22 are compressed to a few micrometers in thickness. The pressure disc 10 provides a plane surface for the diffusion membrane 11, as well as providing an even lateral distribution of the gas entering through the gas inlet openings 9.

The sensor represented in Figure 2 is identical to that in Figure 1, except for the fact that, between th measuring electrode 12 and the wick plate 20, a further reference electrode 24 is accommodated as part of the disc stack. Identical structural components, as are also present in Figure 1, are therefore denoted by the same reference numerals.

The reference electrode 24 is also formed like a disc and is similar in shape to the measuring electrode 12. The reference electrode 24 is porous and thus allows the passage of the electrolyte and of the gas reaction products. The reference electrode 24 is provided with a contact wall 25 which is separated electrically, in a liquid-tight manner, by the sealing ring 7 on the one hand and by an insulating member 26 on the other hand, from the housing 1 as well as from the wall 8 of the cov r 2. The contact wall 25 extends

over the sealing edge 6 of the housing 1 and leaves open a contact region 27 which serves as an electrical contact point for applying a constant reference potential from a measuring and evaluating unit (not shown).

The insulating member 26, as well as the wall 8, have flanges extending over the sealing edge 6 of the housing 1. In this way the dimensioning of the individual structural components are adjusted to each other so that an even peripheral flanged edge is formed. Thus, the sealing ring 7 in Figure 2 is different in its cross-section to that in Figure 1 in that, in the former case, the contact wall 25 also extends around the sealing edge 6. The remaining structural components, in the case of a circularly symmetrical vessel-like housing 1 and vessel-like cover 2, also extend around the whole periphery of the vessel-like housing 1 as is the case with the structural components of the sensor according to Figure 1.

CLAIMS

1. An electrochemical gas sensor for detecting a gas compon nt in a gaseous environment, comprising:

a disc-like measuring electrode to which the component to be detected has access by way of a disc-like diffusion section;

a counter electrode which, together with the measuring electrode, is accommodated in an electrolyte chamber containing an electrolyte inside a vessel-like housing which is in electrical contact with the counter electrode;

a wick immersed in the electrolyte and having a wick plate which bears on the surface of the measuring electrode on the electrolyte side; and

a cover which is in electrical contact with the measuring electrode and which seals the vessel-like housing on the gas side and is separated electrically by a sealing ring from the vessel-like housing;

wherein the cover is a vessel-like cover and has an edge that projects over the outside of the vessel-like housing and accommodates at least the diffusion section and the measuring electrode, the latter having a contact surface;

wherein the sealing ring is disposed around the edge of the vessel-like housing such that, on the one hand, by clamping of the vessel-like cover on the edge of the vessel-like housing, electrical insulation is achieved between the vessel-like cover and the vessel-like housing and, on the other hand, the disc stack is displaced under the effect of pressure against the wick plate which, for its part, is pushed against the disc stack by the presence of a compression spring between the wick plate and the vessel-like housing; and

wherein the edge of the vessel-like cover contacts the contact surface of the measuring electrode and thus forms a contact point for a measuring and evaluating

unit.

2. An electrochemical gas sensor according to claim 1, wherein, between the measuring electrode and the counter electrode, there is arranged a disc-like reference electrode having an edge which projects over the edge of the vessel-like housing and is disposed around it in a sealing manner;

wherein the sealing ring serves as electrical insulation between the reference electrode and the vessel-like housing;

wherein the edge of the reference electrode is separated from the vessel-like cover by an insulating member; and

wherein, on the edge of the reference electrode around the edge of the vessel-like housing, a contact region is available for connection of the measuring and evaluating unit.

3. An electrochemical gas sensor according to claim 1 or 2, wherein the contact surface of the measuring electrode is in the form of a metallic border extending around the outer periphery of the measuring electrode.

4. An electrochemical gas sensor according to any of claims 1 to 3, wherein the vessel-like cover is provided with access openings for the gas to be detected, which openings are sealed by a porous pressure disc with which a diffusion membrane, serving as diffusion section, is in contact, which membrane in turn is followed by the measuring electrode.

5. An electrochemical gas sensor according to any of claims 1 to 4, wherein the wick is in the form of a hollow body which, on the one hand, contains the electrolyte and which, on the other hand, contains the compression spring, which spring has a spring plate which bears against the surface of the wick plate on the electrolyt side.

6. An electrochemical gas sensor according to claim 5, wherein the spring plate is provided with several perforations.

7. An electrochemical gas sensor according to any of claims 1 to 6, wherein the wick plate is covered, up to the measuring electrode, with a partition plate which leaves only a sub-region of the wick plate in electrolyte contact with the measuring electrode.

8. An electrochemical gas sensor according to any of claims 1 to 7, wherein the measuring electrode is a gold-plated nickel gauze in the form of a shell having an edge which as the contact surface bears against the inner wall of the vessel-like cover.

9. An electrochemical gas sensor according to any of claims 1 to 8, wherein the individual discs are pressed against each other, under each other, and sealed to the vessel-like cover by means of fusion adhesive films (for example PFA or FEP).

10. An electrochemical gas sensor according to any of claims 5 to 9, wherein, in the hollow body containing the electrolyte and forming the wick, there is enclosed a gas bubble.

11. An electrochemical gas sensor according to any of claims 1 to 10, wherein the counter electrode is in the form of a pressed metal granulate in the base of the vessel-like housing, in which granulate there is embedded a contact gauze which is connected electrically at a contact point to the housing.

12. An electrochemical gas sensor according to any of claims 1 to 11, wherein the inner wall of the vessel-like housing is provided with a gold lining.

13. An electrochemical gas sensor according to claim 1, substantially as hereinbefore described with reference to, and as shown in, Figure 1 or Figure 2.

Patents Act 1977 **xaminer's report to the Comptroller under Section 17** **(The Search report)**	Application number GB 9319221.9
Relevant Technical Fields (i) UK Cl (Ed.L) G1N (NBPMX, NBPX) (ii) Int Cl (Ed.5) G01N	Search Examiner D J MOBBS
	Date of completion of Search 29 OCTOBER 1993
Databases (see below) (i) UK Patent Office collections of GB, EP, WO and US patent specifications. (ii) ONLINE DATABASES: WPI	Documents considered relevant following a search in respect of Claims :- 1-13

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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Category	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2094005 A (COAL INDUSTRY)	
A	US 3755125 (ENVIROMETRICS)	

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